FOREIGN MATERIAL IDENTIFICATION AND REMOVAL IN THE FOOD SAFETY INDUSTRY

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ABSTRACT

Changes in the food industry including the mass production in response to the globalization of the food chain have led to additional food safety and quality challenges for the food industry. One aspect of these challenges is the effective identification and removal of foreign materials from products. The development and implementation of new manufacturing processes, materials, and techniques can produce many types of foreign materials or contribute to the challenges to their removal. These challenges facing the food industry are requiring more levels of protection along with advances in technologies to help reduce the potential safety and quality concerns of foreign materials. Foreign material identification is important for consumer safety as well as product image and sales. The technologies available for these purposes will be reviewed as well as some traditional methods used as well as some of short comings or problems facing these technologies in the food industry.

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TABLE OF CONTENTS

INTRODUCTION

Food production, consumption, transportation, and the entire food chain have changed drastically over the past few decades and population growth and advances in technology will continue to drive additional changes. The alterations in these processes have created many new and additional challenges to food safety that must be addressed to ensure a safe and secure food supply chain. Globalization of the food industry has allowed for a more expansive food network that allows for products to be quickly spread from distant areas in relatively short periods of time (Trienekens and Zuurbier 2008). This enhances the requirement for a safe product with adequate monitoring and verification controls as any loss of these can be quickly spread to various areas and negatively affects a wide range and number of people. To address this the food suppliers, processors, producers, and all other aspects of the food industry must evolve and continue to increase the level of food safety and the ability to control, monitor, track, or recall product for a multitude of food safety or quality hazards. This has resulted in the expansion of the legal and customer requirements for providing safe products with a high level of quality standards. To meet these requirements the technologies used to carry out food safety and quality processes will need to become more sophisticated and capable of ensuring the safety of a larger food supply and will be required to do so in less time. This paper will look at some of the existing methods that are currently used to control foreign material as well as some developing technologies that may be implemented in the future.

An overview of globalization, its effects on the food supply, and how it is driving changes and expectations in the food industry will be reviewed. Then an overview of food safety and quality will be given and how each one of these can be affected by the presence of foreign materials. The measures that are being implemented by legislative bodies or that are being required by customers for food safety and quality will also be reviewed and how these are affecting producers. Then some of the potential sources of foreign materials in the food chain as well as some of the programs that should be implemented to reduce the likelihood of contamination. This will be followed by currently used foreign material removal or control methods used within the production process to remove or limit product contamination. This will include their uses, effectiveness, as well as proper application to achieve the highest level of safety. Even through the most effective physical control methods there is always the possibility of downstream contamination or failure of separation techniques. The background, uses, shortcomings, and areas of advancement of commonly used methods of foreign material identification will then be reviewed. This will be followed by other technologies that have shown the ability to identify and therefore remove foreign material from the foods. These techniques will be reviewed as well as their potential advantages and areas that must be overcome in the future to become a more viable option.

Globalization

Globalization can be defined as the removal or reduction of barriers for the transport of products, services, ideas, people, or other items across national boundaries. By removing these boundaries the flow of these various items can expand and increase. The results of this are a more connected infrastructure allowing for these products, technologies, and ideas to travel to areas where they were not previously present and to expand much quicker than had been capable of in the past (Kennedy et al 2008). The globalization of the food industry can be seen by the large number of products from other countries that can be found in markets or as ingredients in many products on the shelves. These additional products or ingredients are part of the growing supply of imports of food into various nations. In the United States there has been a steady rise in not only the amount of imported goods but also an increase in the number of supplying nations (Buzby and Roberts 2010). With these imports come the challenges that globalization of the food supply brings with it. Imports are often associated with higher levels of microbial contamination and may be supplied from areas where testing procedures or requirements are less stringent.

This puts the burden on the importers to determine and ensure if the products are safe before being used for consumers. To do this additional and more effective technology will be needed to meet these needs and address these challenges (Buzby and Roberts 2010). For foreign material concerns this can be seen in ingredients, produce, or resale of imported goods that may not be processed in manners similar to those of the importing country. If a food item or ingredient cannot be assured of its safety and absence of foreign material, the producer must be able to find a way to either test for the presence of the foreign material or process the items in a way to ensure removal of contaminants. In the United States the Food Safety and Modernization Act was passed requiring producers to ensure their ingredient suppliers are approved and are properly controlling any known hazards associated with those ingredients or foods. The only way to avoid these supplier verification procedures is if the company controls the risks internally (Food and Drug Administration FSMA 2018). This may lead to companies preferring to mitigate any risks in house and require adequate testing as to not contaminate their own products.

By expanding the food industries reach of products and services we also potentially increase the opportunity for foreign material contamination as well. As food items are prepared and shipped across the world, the potential for contamination of products by microbial, chemical, and physical means can occur at many of the stages during the food chain. As products or ingredients are transported, reworked, or stored it is important to ensure that control measures are implemented to reduce the risk of these contaminants. As this production chain increases in scope and in size it must address the additional links that have been added from farm to fork. These include the many transportation modes, ports, and transfers that occur while traversing a large distance. Some of these stops may be in area with less stringent traceability controls and may allow access to unauthorized individuals. Other aspects that can introduce foreign materials include; inspections, such as customs stops, transfer of containers, or during holding. These foreign materials can be introduced by improperly trained employees, dirty containers, transfer equipment, and can be contaminated by pests if proper precautions are not taken. To overcome these issues as well as meet regulatory requirements transportation companies are now implementing HACCP systems. As in food production facilities this requires the transport companies to identify risks and to implement controls to ensure they do not allow the food to become unsafe (Ryan 2017).

Food Safety and Quality

Food safety can be viewed as the overall system to reduce foodborne illness through preventive means, responding to foodborne disease outbreaks, improving traceability to track food products and ingredients, and provide safe products from farm to fork (Stewart and Gostin 2011). The hazards that must be addressed include physical, biological, and chemical. Biological hazards include bacteria, viruses, or other natural aspects that can cause a food safety risk. Chemical hazards include all natural or synthetic chemicals that could harm someone that consumes an item. Physical hazards, the focus of this paper, include all matter that when introduced into a food product can be hazardous or cause quality concerns (Motarjemi and Lelieveld 2013) .Other aspects of food safety include proper labeling, information technologies, and food defense (Food and Drug Administration FSMA 2018). All of these areas have many smaller aspects that help to create on overall safer product.

A significant contribution to global food safety is the recognition of the Global Food Safety Initiative (GFSI) by many countries and industry members. This in many ways is the most basic stepping stone where most food safety programs and policies begin and where the technologies associated with food safety are implemented. Here the requirements, programs, and procedures can be developed by multiple aspects of the global food industry to help bring some conformity and cohesiveness to international food policies. Although these standards are not required by law they do provide a benchmark for many aspects of food safety. Many suppliers and consumers require some sort of GFSI certification as this standard shows a high level of food safety adherence. An international community with common goals and requirements helps overcome one of the first difficulties with the globalization of the food chain, which is overcoming the multiple different governing bodies and legal requirements differing from country to country. By having a common standard suppliers, producers, and importers have a common way to ensure that food and ingredients meet a certain level of safety (GFSI Overview 2018).

Although food safety and food quality are often connected or associated they are two separate aspects of food production. Food quality is defined in the SQF code (GFSI Certification Code) as a measure of exceeding customer or corporate expectations and a state of being free from defects, deficiencies and significant variation. (SQF 2017). These aspects are separate from those that would cause a customer illness or harm. An example of this could be a hair or soft insect that is found in a consumer’s product. Although this would be unlikely and potentially damaging to the image of the company, there would be little damage or harm incurred if the individual were to consume those items. Besides the presence of non-hazardous foreign materials, other potential quality concerns that are faced by the industry can include visually damaged items, misshaped products, spoilage, or sensory characteristics. Many companies implement GFSI Certification Systems for quality parameters as well (Schoenfuss and Lillemo 2014). Identification of foreign materials and the methods used to control them can also improve some aspects of food quality. As the methods are reviewed, some methods and developing technologies can also improve additional quality factors.

GFSI

Hazard Analysis Critical Control Points (HACCP) program or similar risk based programs are the foundational programs for GFSI certification. These programs identify the risks associated with a process or food production, the steps or limits needed to control the process and create a safe product, and the communication or corrective actions to be taken if a critical limit is exceeded or a product produced is found to be unsafe (Uhlenhopps 2002). Also included are the processes required to verify all procedures are taking place, are effective, and documented to prove completion. In the United States these programs have been expanded to Food Safety Programs and are required by the Food Safety and Modernization Act (Food and Drug Administration FSMA 2018). Hazards are defined as physical, biological, and chemical including radiological agents that can cause illness or injury (FDA guidance 2018). In food safety plan this includes all hazards unintentionally present in the product as well as economically motived adulteration, or addition of items to the process for profit. All hazards that occur in a facilities process that fall into these categories must be addressed along with the means by which to control them (Food and Drug Administration 2017).

Food Recalls

An important aspect of ensuring that products are free of foreign materials besides consumer safety is the possibility of a product recall. After the passing of the Food Safety and

Modernization Act the FDA was granted the ability to initiate a food recall and remove a product from commerce if a company does not voluntarily do so when an issue is discovered (FDA FSMA 2018). There are three types of food safety recalls; Class I- there is a reasonable probability that eating the food will cause health problems or death, Class II- there is a remote probability of adverse health consequences from eating the food, and class III- eating the food will not cause adverse health consequences (USDA 2006). Although these are varying in severity, any food recall could potentially be expensive and cause the company's public perception to be damaged as well. Although only a small fraction of all recalls, 10% of recalls in the United States in 2017 were due to foreign material (Maberry 2018). This resulted in the recall of over nine million pounds of food in 2017 (FSIS 2018).

FOREIGN MATERIAL

Foreign material of any kind can potentially introduce a physical hazard in a food product. These range from natural sources such as rocks, wood, or product components such as shells or bones, to processing components such as metal shavings, equipment parts, or glass pieces from packaging materials. Other potential foreign materials can also be introduced to the finished product at many stages throughout the production of the good such as broken light bulbs, operator contamination, or pest contamination (Manitoba Agriculture 2010). All of these hazards must be evaluated and controlled for each product when producing food. Various governments as well as customers have varying limits on what is identified as hazardous when referring to physical contaminants. In the United States the Food and Drug Administration (FDA) has set the limit as anything between 7mm to 25mm in length is considered hazardous (FDA 2005). Objects less than 7mm must be evaluated to determine if a hazard is present. This is especially important if the product is intended for a more susceptible or at-risk group. Larger items are generally not considered to be hazardous as a consumer would identify the item before eating or placing themselves at risk (Olsen 1998).All of these items that present a potential risk must have control in place to ensure that the final product is safe.

Ensuring a product is safe from physical hazardous is generally completed by multiple steps throughout the production process with added attention at Critical Control Points. Various programs such as pest control programs, good manufacturing programs, foreign material control, receiving and material control programs, and various other programs help lay the foundation for ensuring no physical contamination occurs (Schmidt and Rodrick 2003). Along the process flow depending on the nature of the product, basic technologies are implemented to remove physical contaminants. Often times these include screening or sifting of dried materials, filtering of liquid components, and washing or cleaning of solid materials. These methods are some of the most basic methods but are often very effective and cost efficient methods for controlling foreign materials. To add additional levels of foreign material control; magnets, metal detectors, X-Ray detectors, and new technologies are being implemented to identify and remove foreign materials from food products.

Process Controls

During the production of food materials there are many potential steps or inherent methods that can be implemented to control foreign material. These will depend greatly on the product being produced but the wide range of process controls can be customized to effectively control some of the risks of most processes. Some processes can utilize a wash or spray step to remove foreign materials from certain produce, ingredients, or other products. This basic step can remove many items from the fields or extraneous material as products or ingredients enter a food process. These washes can also be useful in removing bacterial cells or other microbial concerns. This simple method can be effective in removing many quality and safety concerns but must be properly managed as these wash waters can quickly become contaminated and become a source of foodborne pathogens (Luo 2007).

Filtering and Screening

As some products cannot support a wash step other physical separation methods such as screening or filtration can be used to remove the foreign material. These screens can separate solid foreign materials from liquid products or separate solid items based on size. Some systems require mechanical agitation or movement to allow for more effective product flow but the basic method is creating a physical barrier that removes as much foreign material as possible (Motarjemi and Lelieveld 2013) The designs of these systems must take known hazards into account as well as production speed to create the most effective parameters to reduce risk as well as allow effective operation. The advantage of these systems is the low costs and high effectiveness. Like the wash steps though, these separation methods must be adequately maintained and be part of effective food safety systems to ensure they do not become a source of contamination. These screens or filters will wear and break eventually and must be inspected and replaced before they become a source of contamination and introduce metal themselves into the system (Motarjemi and Lelieveld 2013). These systems are effective in removing many hazards and foreign materials but can still fail, create contamination, and cannot stop downstream contamination. For these reasons additional steps may be needed for even further control of foreign materials.

Magnets

Another method of physical foreign material removal is the removal of ferrous metal through the use of various types of magnets. Magnets are the most basic level of metal removal used in the food industry. Often these are used to help protect machinery and help identify any downstream equipment failure (Stier 2017). These magnets vary in composition including; ceramic for general least expensive uses, Alnico magnets which are useful in high temperature processes that can exceed 400°F, and rare earth magnets which are the strongest and most effective but can vary effectiveness at extreme temperature (Wilks 2006). Magnets can remove ferrous materials and rare-earth magnets can also remove magnetic stainless metals as well as weakly magnetic materials. Magnets can also be used and safety control points downstream to remove metal prior to packaging. The advantage of using magnets as a metal removal option is that they can remove many particles, including metal dust and pieces too small for identification by other methods, with very little maintenance, cost, or product loss (Wilks 2006). One of the major disadvantages of magnets is that they can only remove magnetic materials. Other metals, such as aluminum, various stainless steels, and any other non-magnetic metal will not be removed from the product flow. To address these hazards additional control points must be used to ensure product safety (Wilks 2006).

Optical Sorters

Optical sorters and laser sorters are another process control that is commonly used to remove foreign materials or items that do not meet quality parameters from the product stream. These cameras or lasers can detect a multitude of surface level characteristics including color, shape, moisture, and even biological characteristics can be distinguished. Once these differences are identified an air jet or mechanical device can remove the nonconforming material from the surface flow (Motarjemi and Lelieveld 2013). Some studies have shown the ability to use these sorters as an effective measure for foreign material control as part of a HACCP program while also improving product quality through removal of discolored, damaged, and misshaped seeds. This can be even more advantageous for areas with limited resources where additional control measures would not be as affordable (Bayram and Oner 2006).

Metal Detection

To address nonmagnetic metal hazards, many facilities implement metal detectors for removal of hazardous non-magnetic and magnetic metal foreign materials as well as a final check of packaged product to verify product safety. Metal detection was first documented in the early 1800's to protect a Chinese emperor but may have been more similar to a strong magnetic doorway. Electronic metal detection was used to identify a bullet that was lodged in President Garfield in 1881. The technology advanced greatly following World War II due to the need to locate landmines that were left undetonated. Advances to these machines have continued as the advancements in electronics, computers, and sensors have also advanced (Nelson 2004).

Metal detectors have advanced greatly in their abilities to detect metal and to do so with high efficiency. The basic operation occurs by one of two methods; by a balanced coil system using electromagnetic induction or magnetic field systems. In basic balanced coil systems, there are three coils, one transmitting coil and two receiving coils. When an item is placed through the transmitting coil and contains metal, the metal will disrupt the magnetic field that is created by the transmitting coil. The detectors can identify changes in the amplitude and phase of the current caused by metal enters the detection field (Yamazaki 2002) This causes the metal detector to trip and remove the metal from the product flow .These systems can be limited in detection capabilities due to the material that is being tested and the type of metal that is targeted. Materials that have higher conductivity levels, usually due to salt or moisture, can be more difficult to identify metal using balanced coil systems. Magnetic field detectors have a strong magnetic field that can identify magnetic metal inside of aluminum cans and is used solely for identifying metal inside of already sealed cans (Graves and Batchelor 1998). These processes expand on the abilities of magnets to detect additional types of metal and the ability to test post canning.

These basic detectors are common in the food industry and industrial versions continually advance to try and improve the level of detection (size of metal identified), accuracy (percentage of metal removed), and speed all while trying to do so in the most cost effective manner and reducing the amount of false trips and product loss (Choi 2014). Other aspects of metal detection improvements include; operation in various environmental conditions such as heat, vibration, and moisture and the reduction of cross signal effect from machinery or communication equipment (Ries 2017).

One way that metal detection is being researched is to increase the number of transmitters and detectors within the unit. One method that is being researched is to use multiple transmittance frequencies with two perpendicular coil sets to increase the range of size detection with the additional frequencies while also improving the accuracy by expanding the detection angles with the extra set of coils. These methods were shown to be effective in some cases by cross signal noise and interference from the two coils which did cause some difficulties. (Choi 2014). Newer methods looked at increasing the number of frequencies without adding additional coils. This multiscan technology can run five frequencies simultaneously greatly increasing the level of detection, in some cases metal pieces as much as 70% smaller in size. The multiple frequencies help overcome the influence that the metals orientation and composition have on its detection. By reducing this influence the number of missed metal fragments could be greatly reduced (Ries 2017).

If metal is the only hazard or quality concern present for a facility, these me may be effective in controlling a facilities risks. However, if a process has other inherent risks or a facility wishes to identify other nonmagnetic foreign materials, additional or alternative methods must be implemented to ensure product safety and quality.

X-Ray

X-Rays use shortwave lengths they can easily penetrate packaging materials and thus allow for the detection of foreign materials in packaged products. These detectors use high powered energy sources and various imaging systems to produce images of the material and identify foreign materials in packaged materials. In general a high-powered energy source passes the X-ray through the product. The photons are absorbed by various detectors, depending on the machine, resulting in an image of the foreign material. Some pass multiple wavelength or energy levels through multiple detectors to improve the resolution and identification of foreign material in various food medias (Haff and Toyofuku 2008). The ability of these X-ray devices to differentiate even small differences between food and foreign material has been shown detection of metal more effectively and detection of smaller metal pieces than metal detectors. Furthermore, X-rays can detect and identify bones, plastic, glass, and other foreign materials (Haff and Toyofuku 2008).

One key aspect of these detectors is relatively efficient processing speed, which allows them to be effective in industrial settings. X-rays have been shown to detect insect infestation and presence in grain and various produce. At this time, this method has not been shown to be industrially feasible due to volume of product and testing times. The ability of X-ray to detect foreign materials is continually improving and allowing for more sensitive identification. Some developments, such as the use of dark field imaging, are being attempted to increase their ability to detect organic materials on a smaller scale. If these methods are shown to be effective the range of detection for X-rays could be greatly expanded (Nielsen et al. 2010). The cost of the X-ray units and maintenance, processing speed, and the amount of radiation and safety aspects that are associated with it currently limits the use of X-ray detectors (Haff and Toyofuku 2008).

These areas are being improved upon and as advancements are made and costs are reduced the use of X-ray detectors may expand into additional food sectors to improve physical contamination identification. This along with the advancement in algorithms and computer programing also are improving some quality aspects of products as well. This includes the identification of missing components, potential identification of damaged product, and some research believes the potential to identify spoiled product as well (Haff and Toyofuku 2008).

Visual Detection Methods

The visual components of food products and foreign materials are also a field used to identify and remove physical hazards from food products. These methods include various wavelength or imaging sources to visibly identify contamination. One basic optical method using the visible light spectrum is reflectance measurements. Here a light source is used to create a reflectance off the surface of the product and differences between food and foreign material can be detected. This method has been shown to work in some produce production and helps remove sticks, stems, or rocks. Some limiting factors of this method are the heating caused by the illumination and that only surface materials can be detected. This makes testing some sensitive materials and thicker or bulk materials impractical. Other visual detection methods include testing with near-infrared wavelengths of light which uses the absorption ratios of molecular bonds to differentiate the different materials within a sample. Ultraviolet wavelengths can also be used by using radiation of the product and the signal that various materials will reradiate. These methods all vary with efficiency depending on the material being tested and the target foreign material (Graves and Batchelor 1998).

Hyperspectral Imaging

Hyperspectral imaging is a method that combines spectroscopy as well as digital imaging computers. By allowing the use of multiple spectral wavelengths as well as the visible spectrums these methods can be customized to not only detect foreign bodies who do not share similar patterns but additional tests have shown the ability to also identify quality parameters such as the presence of insects, bruised produce, and ripeness detection (Liu et al. 2014). If these additional quality aspects can be combined with the ability to detect foreign materials it can add another level of effectiveness for those industries that find it suitable for their needs. Due to the speed and the many wavelengths that can be incorporated there are many potential avenues this method may be helpful in the future. Some of the disadvantages to this method are the large amount of data that can be collect and the additional research into computations and filters that will be needed in order to be applicable to industry use (Liu et al. 2014).

Thermal Imaging

Thermal imaging can occur in one of two ways typically. If the material and foreign materials give off heat and a suitable range then infrared energy can be applied to the material and then this difference can be used to create a digital image and be used to remove foreign materials. The other method is to apply heat in a short burst then measure how far into the material the heat is able to penetrate. This creates the contrast that allows detectors to identify the foreign material (Ginesu et al. 2004). These methods may not be suitable for all food products but may be able to be adapted to processes where heating or heat treatment of products is already occurring. If these methods could be adapted then these may be a cost effective addition to the process to increase a facilities ability to identify foreign materials.

Additional Methods

Other methods that do not rely on visual wavelengths but still used to detect foreign material usually use a way of excited or differentiating the materials and then using this and a detector to identify the foreign material. This includes the use of microwave ranges which uses moisture levels or microwave impedance to detect the differences between product and foreign material. The advantage to this method is that even small differences are differences between substances can be detected and very small particles can also be identified. Other advantages include the processing speed, wide product range, and wide range of identifiable foreign materials. Some of the disadvantages include adapting the technology to an applicable method that can fit with the current industrial processing environments. Further developments must be made before this is an applicable technology for industry (Edwards 2002).

NMR and MRI

Nuclear magnetic resonance (NMR) and magnetic resonance imaging are two other areas of detection that show future potential for the food industry. These methods use strong magnetic energy fields applied to the food that is being tested. The magnetic field then excite the protons within the nuclei of the cells which then can be measure as they return to their natural state. In doing so this method gives the ability to identify many of the structures, components, and characteristics of the material (Graves and Batchelor 1998). These machines and analytical testing capabilities go much further than the ability to detect the presence of metal or other foreign materials. They can determine quality items ranging from fat and moisture content, concentration of hazardous elements, and identify internal browning within produce. As these units advance they can perform the functions of many other methods such as metal detection, X-ray, and optical sorters while performing additional analytical testing as well. These units still need to advance in areas such as cost, sensitivity of foreign material detection, and testing speed before being applicable to the industry or before replacing current more cost effective measures (Marcone et al. 2013).

Ultrasonic Imaging

Ultrasonic imaging is another potential method for foreign material identification and uses the application of a 20 kHz or larger sound waves to a product and then detecting the resonating frequencies of materials (Graves and Batchelor 1998) or the measurement of sound impedance or time of sound transfer through the material to identify any hazards that are present (Cho and Irudayaraj 2003). These methods have the advantages of being nondestructive and do not negatively affect the tested product. They also have the advantage of being applicable to multiple products and to be cost effective (Cho and Irudayaraj 2003). Previous testing was shown to be more effective in areas when product is transported through water such as a produce facility where water flumes are employed (Graves et al. 1998) but recent studies have shown the ability to detect differences without contacting the material or the need for a conductive medium (Cho and Irudayaraj 2003). Other potential avenues for this method include detection of foreign materials in canned products. These have been able to identify foreign objects in cans as small as 1mm in length but can be negatively affected by container shape and irregularities (Meftah and Azimin 2012). Further development will need to be made if these units are to become used more commonly in the food industry. In process methods may be effective in identifying foreign material but as end of line critical control points they do not seem viable.

Continuous Wave Tetrahertz Imaging

Continuous Wave Tetrahertz Imaging is a method that is being researched to detect foreign material in substances that include organic and low density items which have been difficult for current methods to identify. The goal was to identify less dense materials while still identifying hard materials. This would allow for identification of safety concerns as well as quality concerns such as insect, hairs, or other less dense foreign materials (Lee et al. 2012). Continuous Wave Tetrahertz Imaging is similar to X-ray technology in that it passes radiation energy waves through a product then by measuring the different levels of absorption and transmission a detector can differentiate between different items within a sample. The advantage to the tetrahertz waves is they are not as strong as X-rays and therefore do not pass through less dense materials so quickly. This allows for organic and less dense items to be seen by the detector and to be removed from the product flow. This method has the advantage of being able to detect both dense and less dense material but is not as sensitive at detecting some foreign materials then traditional methods. Another advantage to this method is that it can be applied to some food products that are too sensitive for the higher energies of X-ray detection. Some of the current draw backs to Continuous Wave Tetrahertz Imaging include the lack of current detectors and energy sources in the ranges needed for many food mediums. There is also interaction between these wavelengths and water so only dried products may feasible to test (Lee et al. 2012). If this method can be further developed it may help expand the range where dry products can ensure removal of both hard hazardous materials as well as those that effect quality and customer perception.

CONCLUSION

The collection and production of food products leads to the possibility to contaminate food at many steps throughout the process. With the globalization of the food system this process continues to grow in size and in geographic distance. Foreign material can come from the fields, factories, producers, or during the transport or storage of products. Inadequate removal of foreign materials can lead to potential consumer safety concerns, quality concerns, or product recalls. All of which can be costly and detrimental to the image of a company. Therefore effective cost effective means are needed to remove these potential risks and reduce their potential to reach a consumer as much as possible.

New requirements by legislative bodies as well as customer demands continue to increase the expectations for safe quality food that is free of foreign material contamination. To meet these demands risk-based food safety systems are being implemented to evaluate the risks as well as quality concerns for the industry. Once risks are determined and critical limits are set the overall level and food safety and quality should improve if these systems are followed. To meet these limits process controls can be implemented to help remove and reduce the potential risks of foreign materials. These controls along with effective maintenance and operation programs can allow for the production of products with minimal risk but the potential still exists for further contamination or foreign material getting past in place controls. In these events it is important for facilities to have additional means of identification and removal of foreign materials. Traditional methods such as optical sorters, metal detectors, and X-rays are still the common method throughout the food industry. As technologies improve, these units and their capabilities improve but there inherent nature still has multiple disadvantages or areas for potential improvement. To overcome these shortcomings multiple fields are being researched as to their ability to identify foreign materials as well as add other areas of quality parameter testing. As these methods improve and become more economically feasible, they may become prevalent in the food industry and continue to drive towards safer, higher quality food products.

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